PILOT TRAINING AND PREFLIGHT PREPARATION

By Donald K. Slayton

INTRODUCTION

All phases of the Astronaut training program are discussed herein, including the generalized areas pointed toward all rocket flights and the specialized aspects pointed directly toward the MR-3 flight. Initially, the original qualifications of the trainees should be given. Each is a highly qualified jet fighter pilot who graduated from one of the service test-pilot schools and has experience as an experimental test pilot. Each has a bachelor's degree in engineering or one of the basic sciences, is physiologically and psychologically sound, and is in good physical condition.

Since no ground rules existed for the training of Astronauts at the inception of this program, three basic philosophies were adopted:

(a) Utilize any training device or method which has even remote possibilities of being of value

(b) Make the training as difficult as possible with these devices even though analytical studies indicate the task is relatively easy

(c) Conduct the training on an informal basis except in the interests of intelligent scheduling of instructor and trainer time since we were all assumed to be well-motivated mature individuals.

TRAINING PROGRAM

The training program can be broken down into five major categories as a function of training devices. These categories are academics, static training devices, dynamic training devices, egress and survival training, and specific mission training.

Academics

All of us needed to brush up on basic mechanics and aerodynamics. In addition, prior to this training we had been only briefly exposed to many fields of science such as astronomy, meteorology, astrophysics, geophysics, space trajectories, rocket engines, and physiology. Instructors for these subjects were drawn from the scientists of the Langley Research Center and the Space Task Group. For example, one of the scientists of the Space Task Group gave us a lecture on the principles of rocket engines and rocket propulsion. Dr. William K. Douglas gave us a series of lectures on physiology designed to give us a better understanding of the physiology and construction of the human body, a subject of which we had little knowledge prior to this program. One of the subjects he discussed was the effect on the body of various g-loadings obtained during flight and landing impact.

In addition to the lectures on basic astronautics, we were given detailed systems briefings by the McDonnell Aircraft Corporation engineers concerned with the design of the various subsystems. Also, the engineers within the Space Task Group who were concerned with the various individual systems gave us detailed briefings and continuously brought us up to date with the changes occurring to these systems. Our knowledge of these systems was gained both from formal briefings and from our attending coordination meetings in which these systems were discussed and changes to them made.

As a supplement to the classroom or academic work, we also made many field trips as a group. One such field trip was a visit to the Convair Astronautics Division of the General Dynamics Corporation in San Diego, Calif., where we observed a test facility where the components of the Atlas are tested. We also went to the McDonnell Aircraft Corporation, manufacturers of the Mercury spacecraft, where we had our first look at the mock-up of the spacecraft, and at the basic spacecraft structure and its subsystems being assembled. As a result of this initial visit, we were able to make many recommendations for changes to the cockpit layout and instrument panel, and to recommend incorporation of a single large window and an explosive side hatch for escape. We went to the Redstone Arsenal at Huntsville, Ala., where we observed the Redstone launch vehicle being constructed and checked for flight. We also went to Rocketdyne where we observed rocket engines being constructed and tested. As a group, we visited practically every facility directly concerned with the launching of the Mercury spacecraft. In addition, as individuals, we probably visited every subcontractor involved in the program.

It was obvious quite early in the program that the program was too complex for all of us to command a knowledge of all the detailed aspects of the spacecraft, launch vehicles, and flight. Therefore, by each of us assuming responsibility for one major area, we were able to maintain detailed contacts with all aspects of the program. The following table shows the assignment of specialty areas:

Astronaut	Specialty area
Malcolm S. Carpenter	Navigation and navigational aids
Leroy G. Cooper	Redstone launch vehicle
John H. Glenn	Crew space layout
Virgil I. Grissom	Automatic and manual attitude control system
Walter M. Schirra	Life support system
Alan B. Shepard	Range, tracking, and recovery operations
Donald K. Slayton	Atlas launch vehicle

As an example, I was assigned the Atlas launch vehicle. Where possible, I attended all meetings concerned with mating of the Atlas launch vehicle with the Mercury spacecraft and with modifications to the Atlas launch vehicle which affected our mission. In addition, I observed many Atlas research and development launchings to note procedures which might require change for manned operations. It was then my duty to report my findings and the results of my trips to the rest of our group in order to keep them up to date with the progress of the Atlas. Each of us did the same in his particular specialty area.

A valuable byproduct of the assignment of specialty areas was the ability to get an Astronaut input into the design of each of the systems involved in Project Mercury. We operated essentially in the same manner as the experimental test pilots who work for an aircraft company; we followed through the design phases of our particular area to insure that no obvious operational aspects were overlooked.

Static Training Devices

The next set of training devices used were the fixed-base or so-called static trainers. The first devices were the series of procedures trainers. One early approach used for practicing of retromaneuvers and reentry maneuvers consisted of an analog computer tied in with a locally constructed hand controller and prototype flight instruments to allow us practice in flight control while we were waiting for the production procedures trainer. A modification of that device used the Mercury hand controller and flight instruments and was driven by an F-100 gunnery simulator computer. We could operate this trainer on a contour couch and in a pressure suit, and gain further training in retrofire and reentry.

The final production procedures trainer was constructed by McDonnell Aircraft Corporation. The instructor sat in the outer control console of the procedures trainer. The instruments in the outer control console are essentially the same as within the procedures trainer itself, so the instructor can follow the motions of the pilot onboard. In addition, the instructor is capable of creating any failure mode or emergency that it is possible to encounter with the vehicle, either singularly or in combinations. With this device we have learned to cope with every possible emergency that can occur by developing skill in rapid troubleshooting and in taking appropriate corrective actions.

In addition to use of the trainer for learning modes of failure and corrective actions for failures, we have also run normal mission profiles, for both the Redstone and the Atlas launch vehicles, and any abort profiles that it is possible to obtain, so that we could develop an intimate familiarity with these flight profiles. In the process, we have developed flight plans for our actual flights, since we get an exact feeling for the timing of events and know when we have spare time to do something that is not a mandatory part of the operation. Since this trainer was wired in exactly the same manner as the actual flight spacecraft, and since all spacecraft changes were immediately cranked into the trainer, it has also proved a valuable device in troubleshooting systems design. There have been many cases where a system did not operate exactly as we had envisioned, and we would not have known this fact without having the procedures trainer with which to work. In these cases, we either redesigned the system or modified our procedures to compensate for the changed system.

The next training device we used was the ALFA Trainer, or Air Lubricated Free Attitude Trainer. A contoured couch was mounted on top of an air bearing, which was essentially frictionless, and with the use of a Mercury hand-controller which actuates compressed-air jets, this trainer could be stabilized and controlled about all three axes. Obviously magnitudes of roll and pitch are limited. At first the trainer was completely open; it has now been completely enclosed so that the Astronaut can only see up through the periscope, which is mounted between his legs. On one wall, a screen has been set up upon which the flight path over the earth is projected and with this device we can practice maintaining attitude control by watching through the periscope and also practice navigation around the earth. In addition, compressed-air retrorockets have been attached to the back of the trainer and allow practice in controlling retrofire under dynamic conditions rather than merely by watching instruments as in the initial procedures trainer. We feel our primary backup mode of retrofire would be with the use of the periscope.

Because one-half of our orbital flight path will be on the dark side of the earth, and because some people feel that stars can be seen even on the bright side, it was felt that some training in astronomy was highly desirable. Therefore, we went to the Moorehead Planetarium at the University of North Carolina and were given basic instructions in the location of the various constellations and stars. When we felt that we were fairly familiar with these basic instructions, a Link trainer with a window the exact size of the Mercury spacecraft was installed within the planetarium and we practiced navigation by the stars as we went through an orbital flight path. Since the field of view is rather limited through the Mercury spacecraft window, this Link trainer provided very valuable exercise. We could run through an orbit in approximately 9 minutes and, therefore, obtained a large amount of training in a short time.

Dynamic Training Devices

The next group of trainers are the dynamic or stress-type trainers. The first of these are the weightless or zero-g trainers. Since there is no way to simulate weightlessness on the surface of the earth, we flew in aircraft such as the C-131 through a parabolic trajectory. For these simulations we obtained approximately 15 seconds of weightlessness as we flew over the top of the maneuver. We also flew in the back of the KC-135 where we were able to get approximately 30 seconds of weightlessness. The interior of the KC-135 was well padded and we were allowed to move or attempt to move at will in a free zero-g state. At least for limited periods of time, weightlessness was a lot of fun, and we don't anticipate that it will be greatly different for extended periods of time. This condition of free-floating weightlessness has no direct application to flight in the Mercury spacecraft since in the spacecraft we are strapped in a fairly small cockpit. Therefore, we flew in the back seat of F-100's at Edwards Air Force Base, where we could obtain up to 1 minute of zero-g time while strapped in a fighter cockpit. During this time we could eat food, drink water, and so forth. In general, our impressions were that weightlessness, when we were restrained in an aircraft or in the Mercury spacecraft, was essentially the same as any other g-loading encountered during flight. It doesn't really matter whether the g-force is zero or 2 or -2, because the Astronaut is a part of the vehicle anyway.

As a follow-on to this zero-g or weightlessness training, we went into the centrifuge training or high-g training at the Johnsville human centrifuge. A gondola is mounted on the end of a large revolving arm. Within the gondola we installed a mock-up of our total instrument panel with active flight instruments, driven by the centrifuge computer and our Mercury hand controller, and also a complete environmental control system from the Mercury spacecraft. The gondola was then sealed so that we could depressurize the gondola to the actual flight pressure of 5 pounds per square inch. In this way, we could simulate flying at 27,000 feet with a 5 pound per square inch, 100 percent oxygen atmosphere, and we could note the effects, if any, of applying high-g under reduced pressure. In general, we found no ill effects. We made simulated flights with and without the pressure suit inflated and were able to run through all Atlas and Mercury normal launch profiles and reentry profiles, as well as most of the possible Atlas abort reentry profiles. These abort profiles can call for accelerations as high as 21g but we did not go quite to this level. Some of the Astronauts underwent accelerations of 18g with no excessive difficulty. The primary advantage of the centrifuge was to give us some practice in straining techniques in order to retain good vision and consciousness under high-g loadings and also to develop techniques for breathing and speaking under high-g loads. We also gained practice in controlling the vehicle through the g-load range during the reentry, essentially a rate-damping maneuver. We were also able to tumble the gondola, to go rapidly from a fairly high positive g to a negative g. This tumbling was an attempt to simulate some of our aborts, primarily at maximum dynamic pressure where the accelerations would go from 10g to -10g in approximately 1 second. We feel the centrifuge has been one of our most valuable training devices.

Another dynamic training device was the MASTIF or multiaxis spin test inertia facility at Lewis Laboratory in Cleveland, Ohio. For this device, a seat was mounted within a gimballed frame. A Mercury control handle actuated compressed-nitrogen jets, and Mercury flight instruments were onboard. From an external control station, high-powered nitrogen jets could be actuated which would revolve the device up to 30 rpm about all three axes simultaneously. Our task was then to take over control with the hand controller and, with the use of our flight instruments attempt to bring the rates back to zero and establish our original attitude. We experienced no difficulty as far as the control task was concerned. However, the multiaxis spin test did prove to be a somewhat nauseating exercise after a few runs. This training represents one case of training under extreme conditions which we do not anticipate encountering. The two main cases where we could enter into a tumble-type maneuver would be coming off the booster without any control system operational or having a control jet jam in the open position. In either case, it is anticipated that we could stop tumbling before rates reached any significant magnitude.

We also took an orientation ride in the Revolving Room at Pensacola, Fla. This room rotates at approximately 10 rpm in an attempt to simulate proposals for rotating a large space ship to induce a small g-field artificially, with the assumption that weightlessness becomes a major problem. The object of the room is to show the Coriolis effects present, which are not too apparent until movement is attempted. This rotating room is again a somewhat nauseating experience to many people.

Since the heats of reentry initially were assumed to be of a fairly high magnitude, we dressed in ventilated pressure suits and climbed into a steel box. The interior of this box was heated up to approximately 250° F by radiating heat from quartz lamps through the walls. We found that these temperatures were no great problem at all, and since the time this program was run, we have discovered that out interior cabin heat load during an actual Atlas reentry is considerably lower. We no longer have any qualms about the high heat loads involved.

We also took a ride in the carbon-dioxide chamber at Bethesda, Md. We climbed into the chamber; it was sealed; and the carbon-dioxide content was gradually increased from a normal 0.05 percent to approximately 4 percent over a period of 3 hours. We were able to note the physiological effects such as increased breathing, pulse rate, flushing, and in some cases, a slight headache. We feel that this carbon-dioxide chamber was a valuable part of our training, since no one has been able to devise a completely satisfactory partial-pressure measuring device, at least for measuring small partial pressures. Therefore, we feel that our best indication of excessive carbon dioxide onboard the capsule will be our own sensations.

Another very valuable part of our training has been the flying of high-performance aircraft. Mainly, we flew two F-102A airplanes which we have now converted to two F-106A airplanes. Since we were all brought into this program as highly qualified jet pilots, and since this was one reason we were selected to be Astronauts, we felt that it was highly desirable to maintain this proficiency. Ground simulators and trainers are very valuable for practicing procedures. However, the only penalty for erring in a simulator is to shut down the procedure and start over. We feel that by staying highly proficient as pilots of conventional aircraft, we can maintain our sharpness in making rapid judgments and in reacting accordingly, under somewhat adverse conditions where the penalty for erring is greater than merely shutting down a machine and starting over again.

Another part of our training has been the athletic program. Basically, the athletics have been an individual responsibility. Some of us play hand ball, some run, some swim, and if we feel like doing absolutely nothing, that is our prerogative. We have found that being as competitive as we are, the inducement of keeping up with our fellow troops is adequate to keep most of us working away at maintaining good physical condition. The only organized athletics in which we have engaged has been some SCUBA diving with the Underwater Demolition Team at Little Creek. Here, we eventually became proficient enough to swim a mile underwater fairly easily. We also obtained some additional benefits because of the similarity of underwater swimming to the condition of weightlessness, especially in murky water such as the Chesapeake Bay. Of course, we also developed practice in breathing with an artificial system under pressurized conditions. We also felt that any increase in familiarity with a water environment was desirable since our primary recovery area is in the water.

Egress and Survival Training

Another major section of our training is the egress and survival training. As previously mentioned, our primary recovery area is in the water and, therefore, all of our practice in egressing has been in the water. Initially, we put our egress trainer in a hydrodynamics tank at Langley Research Center and practiced egressing first in smooth water and then in artificially generated waves. When we felt that we had developed a reasonable amount of proficiency in that facility, we took the trainer down to the Gulf of Mexico, near Pensacola, Fla. We took the egress trainer out to sea on a barge, dropped it over the side, and practiced egressing in the open sea, which was quite rough on numerous occasions. Our primary exit for egress is through the small end of the Mercury spacecraft. The Astronaut has the option of dropping out directly into the water and then inflating his raft, or inflating it first and egressing into the raft. This is a method of egress which would be used if the Astronaut decided to get out of the spacecraft before the arrival of the recovery forces.

Another method of egressing was practiced, where it is assumed the helicopters are in the recovery area at the time of impact. The helicopter hooks on the spacecraft and lifts it partially out of the water so that the lower frame of the door is above the water line. The Astronaut then ejects the hatch and climbs out of the spacecraft. The personnel lifting line or "horse collar," as we call it, is then lowered to the Astronaut and, theoretically, he climbs into this and is lifted onboard the helicopter. Our first attempt at the exercise was obviously not too smooth and is another indication of why we need training in these things. Astronaut Shepard used this method of exit on his particular flight without, of course, dropping into the water first. He entered the helicopter completely dry. The advantage of this method of egress is that it is the most rapid way out of the spacecraft and puts the Astronaut onboard the recovery helicopter in minimum time. Also, since a helicopter dropped a spacecraft en route to the recovery area during one early recovery exercise, we haven't had ultimate confidence in riding in the spacecraft while being carried by the helicopter.

The last method of egress is the underwater one. This method would be used, for example, if the spacecraft developed a leak rate after impact of such a magnitude that the Astronaut had insufficient time to get out through the small end. In this case, the Astronaut would have to blow off the side hatch. Once the hatch is off, the capsule rapidly fills with water, and the Astronaut cannot get out until it is completely filled and, hence, sinking. We have found that we can get out under these conditions in around 10 seconds, at which time the small end of the spacecraft is barely under water.

In conjunction with our water egress training, we conducted some water survival training. We spent approximately 1/2 day in one-man rafts learning how to distill water, protect ourselves from the sun, and signal the rescue forces. This exercise convinced us that we could survive for a great number of days if forced to reenter in an unspecified recovery area and await recovery for extended periods of time.

We also spent 3 days learning desert survival techniques at Stead Air Force Base, near Reno, Nev. Here again, we learned how to protect ourselves from the sun, how to utilize the limited water supply, and to build clothing and shelter from our parachutes. There is a remote possibility that we could impact in the west African desert, should our orbital insertion be somewhat under speed and our retrorockets not have adequate thrust. This possibility is very remote, but it is an indication of our attempt to train for any possibility, no matter how remote.

Specific Mission Preparation

We have specific mission preparation which prepares us for an individual spacecraft and an individual launch vehicle. This training covers a period of time of approximately 8 weeks during which the spacecraft is at Cape Canaveral undergoing hangar and pad checkouts. The first object of this training is orientation to the specific spacecraft configurations. Even though all the spacecraft are built to a specific set of drawings and specifications, each is an individual and has peculiarities which are not the same in the others. In order for the Astronaut to become intimately familiar with his particular spacecraft, he participates in all the hangar checkouts on it. He participates in reaction control system checks where he can develop a good feel for his particular control system. This participation is also where we get our primary environmental control system training. The Astronaut rides in the spacecraft when it is put in the pressure chamber for pressure checks, and he operates the environmental control system in conjunction with this checkout. He also attends all meetings concerned with the check-out and modification of the spacecraft, so he is probably the one person most familiar with all details of the spacecraft.

In addition to maintaining a familiarity with the hardware, each Astronaut must practice his specific mission flight plan since each mission is somewhat different. He does this in the procedures trainer, where he runs time and time again over the flight plan which has been laid down for his particular mission. He also runs through all emergencies that anybody can envision happening. During this time, Astronaut performance data is procured for comparison with flight-test results after the flight.

In addition to the pure Astronaut training flights, each Astronaut also practices with the Mercury Control Center flight controllers and the down-range stations involved in his particular flight. The procedures trainer is tied into the Mercury Control Center, and simulated missions are flown while various emergencies are simulated primarily to test the flight controllers. In the process of these exercises, ground rules and mission rules are evolved which apply to this particular mission.

Once the spacecraft is moved to the pad and mated with the booster, the Astronaut then participates in all practice countdowns, radio-frequency compatibility checks, simulated flight tests, and so forth. Detailed launch procedures are developed with the pad crew. Astronaut ingress training is also obtained at this time. In addition, the emergency pad rescue crew is also exercised and techniques are developed for rescuing the Astronaut on the pad should some emergency develop prior to the launch. These are also full-scale training programs, with all personnel involved participating. During this latter period of training the Astronaut is also concentrating on maintaining himself in the best of physical condition. Medical personnel are continuously monitoring his health and insuring that he stays healthy during this period. Part of this program involves placing the Astronaut on a special low-residue diet and collecting specimens for comparison with post-flight specimens.

DISCUSSION

The success of any training program can only be evaluated when compared with an actual flight. It appears that our training was entirely adequate for this flight and that nothing was missed. As expected, some facets of the training program proved to be of relatively little value and will probably be eliminated from future training. On the other hand, some items proved to be of very great value, and we will probably place much greater emphasis on these facets in future training.